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Continental rift processes determined by spatiotemporal development of faulting and magmatism in the Rio Grande rift, USA

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Analysis of low-temperature thermochronometric data in the Rio Grande rift (RGR) in New Mexico and Colorado, USA provides the means to assess the timing of fault initiation and patterns in growth and linkage of rift faults. Evaluating spatiotemporal patterns in faulting and rift-related magmatism reveals insights into processes behind extension accommodation and helps to distinguish between possible rift models. We separate the RGR into three sections (north, central, and south) based on physiographic differences in faulting and magmatism and combine new apatite (U-Th-Sm)/He (AHe) and zircon (U-Th)/He (ZHe) thermochronometric data with previously published AHe and apatite fission track (AFT) data to compile 14 vertical transects, spanning more than >800 km along the RGR axis. Rift initiation appears to be contemporaneous at ca. 25 Ma on fault segments in both the northern and southern RGR. Fault initiation continues with segment growth and linkage from ca. 25 to ca. 15 Ma. At ca. 15 Ma the entire rift system becomes fully linked through strike-slip faulting and magmatic accommodation in the central RGR.

Major structures associated with rift formation in the northern and southern sections of the RGR are spatially coincident with recognized north-south oriented Ancestral Rockies structures (the Central Colorado Trough, Orogrande and Estancia Basins, and Frontrange, Apishipa Sierra Grande, and Pedernal uplifts). Conversely, the central, non-exhumed section of the RGR is coincident with the southwest-northeast striking Jemez lineament, which is recognized as a possible boundary between the ancient Yavapai and Mazatzal terranes. The central RGR is also spatially coincident with a south-to-north transition from thinner to thicker lithosphere that accompanies a change from a wide rift with multiple faults accommodating extension to a narrow rift focused on single basin-bounding structures. We suggest that rift structures in the RGR preferentially localize along pre-existing crustal weaknesses inherited from earlier orogenic events including the Ancestral Rocky Mountain and Laramide orogenies, and that rift style and extension mechanisms are controlled by lithospheric-scale structure. These new analyses and interpretations provide a framework for assessing rifting models, and we suggest that a possible RGR model involves initiation of fault accommodated extension by oblique strain followed by block rotation, where extension in the RGR is accommodated by a combination of faulting (southern and northern RGR) and magmatism (central RGR).